System Performance of the Joint Galileo/Mars Observer/Ulysses 1993 Gravitational Wave Experiment

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From March 21 to April 11, 1993 the Galileo, Mars Observer, and Ulysses spacecraft were tracked almost continuously in a coincidence experiment to search for low-frequency (~millihertz) gravitational radiation. In the spacecraft Doppler technique, the earth and a distant spacecraft act as separated test masses. A very pure microwave signal is transmitted from a Deep Space Network ground station. The signal is coherently transponded by the spacecraft, allowing measurement of the relative dimensionless velocity, $\Delta v/c$, of the earth and the spacecraft. A gravitational wave incident on this system causes perturbations in the time series of Av/c that are of order the gravitational wave strain amplitude, h. The detailed signature of the wave depends on the gravitational waveform, the earth-spacecraft distance, and the angle the gravitational wavevector makes with the earth-spacecraft line (Estabrook and Wahlquist *Gen. Rel. Grav* 6, 439 (1975)). After removal of the known orbit and calibration for other known motions of the spacecraft, a search can be made for such waves. This is the first low-frequency gravitational wave coincidence experiment and will allow very strong suppression of noises that are not common-mode in the three time series.

Because the signal amplitudes are anticipated to be small ($h \sim 10^{-15}$ or smaller), careful attention to noise sources is required. We report here a first statistical assessment of the noise characteristics of the data, with particular attention to the performance of the radio science instrumentation itself.